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Mobility and Human Factors Evaluation of Three Prototype Assault Snowshoes

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The Human Research and Engineering Directorate (HRED) of the U.S. Army Research Laboratory (ARL) conducted a mobility and human factors evaluation of candidate assault snowshoes for the U.S. Marine Corps Systems Command from 15 through 20 February 1993. This evaluation compared the performance and attitudes of marine subjects using the standard military snowshoe and three candidate assault snowshoes. The performance data consisted of timed trials for negotiating an assault course, getting into and out of the prone firing position, donning, and doffing. Marines subjectively rated the snowshoes at various times throughout the evaluation. The results indicated that marines negotiated the assault course and got into and out of the prone firing position significantly faster and with more ease with the candidate assault snowshoes than when using the standard military snowshoe. The results also showed that marines could don Snowshoe C faster than the other snowshoes and that none of the snowshoes were difficult to remove. Marines subjectively rated the candidate assault snowshoes higher than the standard snowshoe for most characteristics and features. Subjective data also indicated that Snowshoe A was the most preferred candidate snowshoe. None of the candidate snowshoes evaluated are acceptable for military usage without implementing some design changes to correct the shortcomings noted in this report.

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MOBILITY AND HUMAN FACTORS EVALUATION OF THREE PROTOTYPE ASSAULT SNOWSHOES

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MOBILITY AND HUMAN FACTORS EVALUATION OF THREE PROTOTYPE ASSAULT SNOWSHOES

INTRODUCTION

The United States Marine Corps (USMC) has missions in geographical areas that require marines to use cross-country skis and snowshoes. The current snowshoe was designed to support the weight of the marine and a sustainment load during cross-country movement in snow-covered environments.

The current marine concept of operations is that the marine will ski to the objective, remove his sustainment load and skis, and conduct the final phase of attack on snowshoes with an assault load. This load consists of weapons, ammunition, and load-carrying and mission-essential equipment only.

A problem arises when the marine makes the assault on snowshoes; the size and weight of the current snowshoe degrade the marine's agility and ability to maneuver rapidly to the objective. As a result, the USMC has a requirement to supplement the primary over-the-snow method of movement with an assault snowshoe. The primary purpose of the assault snowshoe is to provide the marine with a lightweight snowshoe that will enhance maneuverability during the final phase of attack.

The Marine Corps Systems Command (MARCORSYSCOM) asked the Human Research and Engineering Directorate (HRED) of the U.S. Army Research Laboratory (ARL) to evaluate mobility and human factors of three candidate snowshoes. This study was conducted at the Marine Corps Mountain Warfare Training Center, Bridgeport, California, from 15 through 20 February 1993.

This evaluation compared the performance and attitudes of marine subjects using the standard military snowshoe (trail magnesium snowshoe) and three candidate assault snowshoes. The performance data consisted of timed trials for negotiating an assault course, getting into and out of the prone firing position, donning, and doffing. The marines subjectively rated the snowshoes at various times throughout the evaluation. Compatibility, human factors, and durability problems observed during the study were also recorded.

OBJECTIVES

A mobility and human factors evaluation was conducted to

a. Determine the relative effects of snowshoes on the ability of marines to maneuver through various courses (developed on site).

b. Determine if the snowshoes allow the user to get into and rise from a prone position rapidly and with minimal effort.

c. Determine if the snowshoes are easy to don and doff.

d. Determine if the snowshoes are compatible with the cold weather footwear that is issued to marines.

e. Determine user acceptance for each candidate snowshoe.

f. Identify human factors and durability problems that occurred within the scope of the evaluation.

SUBJECTS

Twelve male marines from the Marine Corps Mountain Warfare Training Center (MCMWTC), Bridgeport, California, volunteered to participate in this evaluation. These marines were all experienced noncommissioned officers (NCOs) assigned permanently at the training center, and all were instructors for cold weather operations and survival. The marines' medical records were reviewed by a medical officer at the MCMWTC to assure that none had medical histories or recent injuries that would exclude them from the study. All were approved to participate in the study.

HRED personnel gave a pretest briefing. The subjects were assembled and given an orientation about the purpose of the test and their participation. After the briefing, the subjects were given a volunteer consent affidavit to read. After all subjects read the affidavit, they were given the opportunity to ask and have answered all questions pertaining to the test and their participation in it. All 12 marines then completed and signed a volunteer consent affidavit (see Appendix A).

The anthropometric body measurements of stature and weight were made for each subject. These measurements and each subject's boot size were recorded and are shown in Table B-1 of Appendix B. The summary statistics for the measures of stature and weight for this subject group are shown in Table B-2. Results of the summary statistics show that this subject group was both taller and heavier than the means of those given in the 1977 anthropometric survey of U.S. marines and of those given in the 1988 anthropometric survey of U.S. soldiers.

Because of physical problems, Subject 6 did not participate in any of the trials, and Subject 11 participated only in the first four trials. Neither physical problem was the result of this study.

APPARATUS

Mountain Warfare Training Center

This evaluation was conducted at the Mountain Warfare Training Center, Bridgeport, California. The first 3 days (six trials) were conducted in an area called Silver Creek (elevation 9,000 feet) which was approximately 5 miles from the lower base camp at Pickle Meadows. The location was changed to the Upper Bench (elevation approximately 8,000 feet) for the last day (two trials) because a snowstorm created almost white-out conditions and made it unsafe to transport personnel to Silver Creek. Both areas were suitable because of their similarities. Each had a flat open meadow, gently rolling hills with wooded terrain, and a steep sloped area. A mobility course was marked in both areas. Each course consisted of a cross-country course, a steep sloped course, and a 75-meter assault course.

Cross-Country Approach March Course

The courses were marked in wooded areas (trees and brush) on the gentle rolling hillsides approaching the steep sloped area. These courses were used for the approach march and were intended to force the subjects to maneuver through various wooded foliage and terrain. Movement through the wooded area required the subjects to manipulate the snowshoes between standing trees, through bushy foliage, up and down trenches or gullies, and over rolling

terrain. The purpose of this type of course was to provide the subjects with a period of sustained usage from which they could form opinions for subjectively rating the snowshoes. The courses were approximately 2.5 km long.

Steep Slope Course

These courses were marked on a steep slope in areas adjacent to the assault courses. The courses were designed so that the subjects had to climb 50 meters, traverse 50 meters across the slope, and then descend 50 meters. These courses enabled the subjects to rate the traction capabilities (bindings, traction bars, or gripper teeth) of each snowshoe and their abilities to climb, traverse, and descend a steep slope using each snowshoe.

Assault Course

The assault courses were 75 meters long and lay in the flat open areas of the meadows. Avalanche probes were placed into the snow at the starting line and at 25, 50, and 75 meters from the start. The 25- and 50-meter probes designated the area where the subjects got into and out of the prone firing positions, and the 75-meter probe was used to designate the course finish. These courses, which were relatively short-term, high-energy expenditure performances when body and equipment interactions were most likely to occur, forced the subjects into activities (i.e., running, balancing, and falling into and rising from the prone firing position) that might be required during the final phase of an attack.

Snow-Measuring Device

This was an HRED shop-fabricated device used to take snow depth measures at the test sites. The device was made by threading a 2-foot-long (3/4-inch outside diameter) black iron pipe to the center of a 1/2-inch-thick aluminum disc 12 inches in diameter. Fifteen pounds of weight (three barbell discs at 5 lb each) were placed over the pipe and onto the top of the disc. The total weight of the device was 22-1/2 lb.

Clothing and Equipment

The subjects were required to wear or carry the clothing and equipment items listed in Table 1 during each cross-country approach march and when negotiating the steep slope courses. The pack, its contents, and the two canteens were removed before the subjects negotiated the assault course.

Test Items

Three different candidate assault snowshoes were evaluated and compared to the standard snowshoe. The size and weights of each snowshoe are listed in Table 2. Photographs of each snowshoe are shown in Appendix C.

Table 1

Clothing and Equipment Items

Clothing and equipment items	Weight (lb)
Clothing	
Polypropylene underpants	0.82
Polypropylene undershirt	0.68
Polypropylene liner sock	0.10
Wool-polypropylene insulating sock	0.23
Cold weather field trousers	4.00
Extended cold weather clothing system (ECWCS) polytetrafluorethylene (PTFE) parka with hood	1.85
Extreme cold weather glove	0.81
Extreme cold weather boot, white insulated	6.20
Gaiters, snow and ice	0.70
Balaclava	0.35
Equipment	
Large internal frame pack	8.50
Clothing, equipment, rations (in pack)	9.86
Canteen, cup, cover with 1 quart water (two each)	6.64
M16A2 rifle	7.20
Total load weight (cross-country and slope course)	47.94
Total assault load weight	22.94

PROCEDURES

Training

No specialized training scenarios were required because the subjects were all experienced users of snowshoes. However, all subjects were shown proper procedures for donning and doffing the snowshoes and were required to practice and conduct two error-free donning and doffing trials before the timed trials began.

Table 2

Test Items - Prototype and Standard Snowshoes

Item	Manufacturer	Model	Size (inches) (length x width)	Weight (lb)
A	Atlas	1022	22 x 8.5	2.9
B	Redfeather	Harrier	26 x 8.5	2.9
C	Tubbs	Katahdin	25.5 x 8.5	3.5
S	Military standard	Trail Magnesium	40 x 11.2	6.8

Weights listed are per pair including bindings. The weights for prototypes A, B, and C also include crampons.

Scenario

Each morning, the experimenters and subjects met in a classroom at the lower base camp. The snowshoes that each subject would use that day were issued. All necessary equipment was then loaded into snow terrain vehicles. The experimenters and subjects then entered the vehicles and were transported to the test site. Upon arrival, the equipment was unloaded from the vehicles. After the subjects met at the test site, they donned the snowshoes, clothing, and equipment necessary to conduct the mobility trials. When ready, each subject walked into an area of fresh snow and had flotation measurements (the depth to which snowshoes sank beneath the snow surface) taken and recorded for the snowshoe he wore. Measurements were also made and recorded using the snow-measuring device. An experimenter lowered the device gently so that the bottom of the disc had just barely touched the snow. The device was then released to drop into the snow. The depth to which the device sank into the snow was then recorded. After all measurements were made, the subjects started the morning mobility trials.

The first event was the cross-country approach march. The subjects marched in a single file column for the entire distance. Each subject led the column (broke the path in fresh snow) for 4 minutes, stepped to the side, and then fell in at the rear of the column. The approach march ended only after each subject took his turn leading the column. The subjects were given a 15-minute rest period immediately after the march. The length of the march varied because of the snow conditions but was estimated to have been from 2 to 2.5 km.

Next, each subject walked to the start of the steep slope course. Each subject then negotiated the course by climbing the slope for 50 meters, traversing the slope for 50 meters, and descending the slope for 50 meters. The subjects were then given a 15-minute rest period before proceeding to the 75-meter assault course.

The final phase of the trial required each subject to negotiate a 75-meter assault course as fast as possible. The packs were removed before the subjects ran the course. When given an audible signal to start the course, the subject ran to the 25-meter mark where he got into and out of a prone firing position. He then ran to the 50-meter mark and again got into and out of a prone firing position; he then continued to the finish line. The total course times and the times required for each subject to get into and out of each prone firing position were recorded.

Experimenters were careful to record comments made by the subjects and any human factors and durability problems observed during the trials.

This scenario was repeated in the afternoon after a lunch and rest period. The subjects wore the same snowshoes for the afternoon trials as they did for the morning trials. This gave the subjects a reasonable amount of time to evaluate the snowshoes.

After the daily mobility trials were completed, the equipment and personnel were loaded into the vehicles and transported to the lower base camp. The subjects met there, and donning and doffing trials were conducted. After completing two successful training trials, the subjects participated in two test trials in which they donned and doffed the snowshoes they had worn that day. They completed one test trial while wearing gloves, and the other trial was completed while bare handed. The times required to don and doff the

snowshoes for each hand condition were recorded. The subjects next completed questionnaires and participated in a debriefing session. This daily scenario was repeated on 4 consecutive days until each subject used each snowshoe type.

Two marines, who were the only ones that owned Alcoe ski boots and who wore the smallest and the largest boots, participated in an abbreviated fitting session at the end of each test day. The subjects donned the Alcoe single ski boots and then donned and adjusted the snowshoe they had worn that day over these boots. The snowshoes were also donned and adjusted over the Merrell two-piece ski boots. Any observed fitting or compatibility problems were noted.

After the mobility trials were completed, all subjects conducted trials to assess the compatibility of the snowshoes with the Merrell two-piece ski boot. Half of the subject group conducted a trial with Snowshoe A, then B, or vice versa, and the other half conducted a trial with Snowshoe C, then S, or vice versa. Each trial required the subjects to don the ski boots and snowshoes, then negotiate the steep slope and assault courses. The problems that were observed were noted.

All subjects completed posttest questionnaires and participated in a final debriefing session after the mobility trials were completed.

TEST DESIGN

Independent Variables. Snowshoe types.

Dependent Variables. The dependent variables were

a. Flotation measurements

b. Times to negotiate assault course

c. Times to get in and out of prone position

d. Times to don and doff snowshoe

e. Questionnaire response data

f. Debriefing comments

g. Human factors observations

h. Durability observations

Test Matrix

A balanced repeated measures design was used to expose each subject to a different snowshoe each day. The presentation order used is shown in Table 3.

Table 3

Presentation Order

Subject	Day 1	Day 2	Day 3	Day 4
1	A	B	C	S
2	C	A	S	B
3	B	S	A	C
4	S	C	B	A
5	A	C	S	B
6	S	A	B	C
7	C	B	A	S
8	B	S	C	A
9	S	B	C	A
10	C	S	A	B
11	B	A	S	C
12	A	C	B	S

Subject 6 did not participate in any of the trials, and Subject 11 completed only the first four trials.

OBJECTIVE MEASURES

Flotation Measurements

Flotation measurements were made on the depths to which the subjects sank into the snow while wearing the snowshoes. A lightweight piece of lattice (board) was placed across the span of the depression in the snow. Measurements were made from the deepest part of the indentation made by the snowshoes to the bottom portion of the board. Measurements were recorded to the nearest 1/4 inch.

Timed Trials

The times required for subjects to negotiate the assault course, get into and out of the prone firing position, and to don and doff the snowshoes were measured with a stopwatch. Times were recorded to the nearest 1/10 second. Durability and human factors problems were recorded as observed.

SUBJECTIVE EVALUATION

Subjective questionnaires were designed to solicit subjects' opinions about the snowshoes worn during the mobility trials. Daily questionnaires were designed so that the subjects could rate the snowshoe worn each day.

Posttest questionnaires were designed so that the subjects could make comparisons among the different snowshoes used. The questionnaires are shown in Appendix D.

Daily Questionnaire

Each subject was given a five-point rating scale questionnaire to complete after each test day. This questionnaire required the subjects to rate general and specific characteristics for the snowshoe used that day. The subjects were instructed to select the adjective (excellent, good, acceptable, marginal, or unacceptable) that best expressed their opinion for each rating about the snowshoe. The subjects were also encouraged to write additional favorable or unfavorable comments on the bottom or back of their questionnaires.

Posttest Questionnaires

Questionnaires that consisted of semantic differential rating scales, paired (head to head) comparisons, and overall system choice were given at the end of the evaluation.

Semantic Differential Rating Scales

These questionnaires required each subject to rate general and specific characteristics for each of the candidate assault snowshoes. The subjects were given three questionnaires, one for each candidate snowshoe. They were asked to make comparative judgments between that candidate snowshoe and the standard magnesium trail snowshoe. They were instructed to rate the characteristics of each candidate, considering the standard snowshoe as the midpoint of the dimension line serving as the comparison or anchor point for each comparative judgment. Movement to the right or left of the anchor point represented an increasingly favorable or unfavorable (depending on polarity of words or phrases) judgment for each rating. The subjects were told to mark the circle that best expressed their opinion about each judgment.

Paired Comparison Questionnaire and Overall Choice

In this technique, the snowshoes evaluated were paired against each other in a questionnaire test booklet. Each page of the booklet contained one comparison (two snowshoe types) and criteria for the selection. Each subject was forced to choose one type of snowshoe from each paired comparison as being superior to the other; then he was required to choose the one criterion that best described the reason for his choice. The subjects were instructed to select only one choice per pair, check the box that showed the main reason for their choice, turn the page to the next comparison without looking back to previous pages, and turn the booklet over when they were through. The snowshoes were available for the subjects to look at and handle throughout the administration of this questionnaire.

When all subjects had completed the test booklet, the following instructions were given:

Now that you have compared each snowshoe to every other snowshoe, we would like you to make an overall choice. Based on all of the experiences you have had during this evaluation, select the one snowshoe that you preferred the most. Now that you have selected an overall choice, we would also like you to select the snowshoe you preferred most for the cross-country approach march, for the assault course, for climbing the steep slope, for traversing the steep slope, and for descending the steep slope.

RESULTS

Objective Measures

Objective data were recorded for snow device measurements, snowshoe flotation measurements, and various timed performance trials. The performance trials consisted of times required to negotiate the assault course (including times to get into and out of two prone firing positions) and the total times required to don and doff the snowshoes. The data for these measures were collated and subjected to various analyses of variance (ANOVAs) to determine if there were statistically significant differences ($p < .05$) among the snowshoes. These analyses were checked for compound symmetry. If the assumption for compound symmetry was rejected, the conservative Greenhouse and Geisser adjustment for the degrees of freedom was performed. If any analyses determined that statistical differences existed between snowshoes, a post hoc analysis was performed using a Scheffé Test to determine the statistical differences between the mean scores.

A *correlation analysis* was conducted to determine if subjects' body weights or the daily snow device depth measures (covariates) influenced the dependent measures for times required to negotiate the assault course (including prone firing position times) and for snowshoe flotation measurements. The results (see Appendix E) showed that there was a high correlation ($r = 0.90$) between snow device measurements and the dependent measures. Because of this correlation, the daily snow device measures were used as the covariate in the ANOVAs conducted on assault course times (including prone firing position times) and the snowshoe flotation measurements.

Snowshoe Flotation Measurements

The measurement data recorded for the depth to which the snowshoes sank into the snow were collated and subjected to an ANOVA. The results of this analysis (see Appendix F) determined that there were no statistical differences among the snowshoes. The mean flotation measurements for Snowshoes A, B, C, and S were 10.45 inches, 9.99 inches, 8.91 inches, and 8.24 inches, respectively.

Assault Course Times

These data were collated and subjected to an ANOVA. The results of this analysis (see Appendix G) show that there were statistical differences between at least two of the snowshoes. Scheffé's Test was used to determine the differences between mean times. The results of this test (see Table 4) show

that the subjects' times were significantly worse (slower) when they wore the standard snowshoe than when they wore any of the candidate assault snowshoes. There were no significant differences among the candidate snowshoes.

Table 4

Scheffé's Test for Assault Course Time

Mean time in seconds	Snowshoe type	C	A	B	S
28.3	C				**
28.6	A				**
30.3	B				**
36.7	S				

** Indicates significance at the .05 α level, df=27, MSE=31.05

Prone Firing Position Times

The times required for subjects to get into and out of the prone firing position at the 25- and 50-meter marks were subjected to ANOVAs. The analyses (see Appendix G) determined that there were statistical differences between at least two snowshoes at the 25-meter mark. Scheffé's Test (see Table 5) determined that the time required for subjects to get into and out of the prone firing position at the 25-meter mark was significantly slower when the standard snowshoes were worn. There were no significant differences among the candidate snowshoes.

The results of the analysis of prone position times recorded at the 50-meter mark indicated that there were no significant differences among snowshoes.

Table 5

Scheffé's Test for Prone Firing Position Time at 25-Meter Mark

Mean time in seconds	Snowshoe type	A	B	C	S
2.36	A				**
2.49	B				**
2.54	C				**
3.49	S				

** Indicates significance at the .05 α level, df=27, MSE=0.48

Donning and Doffing Trials

The times for the donning and doffing trials were collated and subjected to an overall ANOVA. The results of this analysis determined that there was a statistically significant difference ($p < .05$) between the bare-handed and

glove-handed conditions for both donning and doffing. Because there was a significant difference between hand conditions, separate analyses were conducted on the bare- and glove-handed data conditions. The results of the analyses of the donning time data determined that statistical differences ($p < .05$) existed between at least two of the snowshoes for both the bare-handed and glove-handed conditions (see Appendix H). The results of Scheffé's Tests for the bare-handed donning times and for the glove-handed donning times are shown in Tables 6 and 7. The results (see Table 6) determined that it took significantly longer to don Snowshoe B than it did to don Snowshoes C and A when bare handed. The results (see Table 7) of the glove-handed trials show that it took significantly longer to don Snowshoe B than it did to don Snowshoes C, S, and A; it also took significantly longer to don Snowshoe A than it did Snowshoe C.

Table 6

Scheffé's Test for Bare-handed Donning Time

Mean time in Seconds	Snowshoe type	C	A	S	B
30.0	C				**
37.7	A				**
41.3	S				
52.6	B				

** Indicates significance at the .05 α level, df=28, MSE=165.96

Table 7

Scheffé's Test for Glove-handed Donning Time

Mean time in seconds	Snowshoe type	C	S	A	B
42.8	C			**	**
71.3	S				**
84.6	A				**
121.9	B				

**Indicates significance at the .05 α level, df=28, MSE=1119.68

The results of the analyses of the doffing trial data show no significant differences among snowshoes, but there was a significant difference ($p < .05$) between hand conditions.

Subjective Measures

Subjective data were collected on daily and posttest questionnaires to solicit the subjects' opinions about the snowshoes used during this evaluation.

Daily Questionnaires

Five-point rating scale questionnaires were given to each subject at the end of each test day. The raw scores were collated and used to compute descriptive statistics and to conduct chi-square analyses (Pearson statistics) for each rating on the daily questionnaire. The mean rating scores and standard deviations (SDs) for each snowshoe are shown in Table 8. The results of the chi-square analyses show that the prototype snowshoes (A, B, and C) were significantly better than Snowshoe S for the ratings pertaining to overall size, maneuverability, negotiation of terrain and obstacles, climbing, running, and dropping into and rising from the prone firing position. The results also indicated that Snowshoes C and S were significantly better than Snowshoe A for the rating pertaining to size of the toe hole. The standard snowshoe, S, was significantly better than all the prototype snowshoes for the rating on snowshoe flotation.

The subjects were also encouraged to write additional comments (favorable or unfavorable) they had about each snowshoe. These comments were tabulated and are shown in Table 9. The numbers in parentheses indicate the number of subjects who made the comment.

Semantic Differential Rating Scale Questionnaires

The subjects used 18 bipolar pairs of words or phrases to make comparative judgments between each candidate assault snowshoe and the standard snowshoe. The raw scores from these questionnaires were used to compute the means and SDs and to show the total number and percentages for favorable, neutral, and unfavorable responses shown in Table 10. The ratings considered positive or favorable are those with mean scores ≥ 5.0. Ratings with mean scores ≤ 3.0 are considered as negative or unfavorable. The majority of the ratings for the candidate Snowshoes A, B, and C were positive or favorable. The only favorable rating for the standard snowshoe was for the characteristic pertaining to flotation. The raw scores were also used to conduct chi-square (Pearson statistics) analyses for each rating on the questionnaire. The results of the analyses show that Snowshoes A and B were rated as significantly easier to run with in the snow than Snowshoe C and that Snowshoe A was significantly easier to climb with than Snowshoes B and C.

Paired Comparisons

The data from the paired comparison tests were collated and used to construct the incidence matrix shown in Table 11. Each column represents the number of times a snowshoe was selected (preferred) when compared against the other snowshoes. For example, Column A shows that Snowshoe A was selected seven times when paired against Snowshoe B, nine times when compared against Snowshoe C, and nine times when compared against Snowshoe S. These data were subjected to analyses for paired comparison data. These analyses provided scaled object indices which ranked the snowshoes from the most preferred (Snowshoe A) to the least preferred (Snowshoe S). The Additivity Test (chi-square = 4.843, df = 3, probability of occurrence = 0.1836, which is not significant) indicates that the subjects' choices were consistent. The data were then subjected to an ANOVA. The value $F = 7.971$, and $p = 0.061$, indicates that there were no statistically significant differences between snowshoe rankings. The results of the analysis for paired comparisons are shown in Appendix I.

Table 8

Summary of Responses from Daily Five-Point Rating Scale Questionnaires for the Four Snowshoes Evaluated

Features or characteristics rated	Snowshoe A mean	A SD	Snowshoe B mean	B SD	Snowshoe C mean	C SD	Snowshoe S mean	S SD
Ruggedness	4.18	0.87	4.27	0.65	4.40	0.70	4.20	0.79
Overall size	3.67	1.03	3.82	0.75	4.20	0.92	2.40	0.70
Weight	4.45	0.52	4.45	0.52	4.70	0.48	2.40	0.84
Width	4.09	0.83	4.00	0.77	3.90	0.88	2.60	0.84
Length	3.73	1.19	3.82	0.98	4.20	0.79	2.40	0.83
Fit	3.64	0.92	3.82	0.98	4.20	0.79	3.30	0.95
Ease of use	3.73	0.90	3.91	1.14	3.80	1.03	3.30	0.95
Ease of donning	3.82	1.08	2.73	1.10	4.50	0.71	3.90	0.74
Ease of adjusting binding straps	3.36	1.29	2.73	1.35	4.10	0.99	3.70	1.06
Stability of boot in binding	3.73	1.27	3.64	0.92	4.00	1.05	2.90	0.88
Size of toe hole	3.36	1.36	4.00	0.63	4.30	0.67	4.40	0.70
Compatibility w/vapor barrier boot	3.55	1.37	4.09	0.94	4.60	0.52	4.40	0.97
Retention of binding straps	3.09	1.22	4.00	0.89	4.00	1.25	3.10	1.10
Ease of doffing	4.27	0.79	3.91	0.70	4.60	0.70	4.20	0.92
Ability to stay afloat on Snow	3.36	1.03	3.27	0.90	3.50	1.18	4.80	0.42
Ability to walk in snow	3.73	1.01	3.73	0.79	4.10	0.88	4.10	0.88
Ability to maneuver	4.73	0.65	4.27	1.01	4.20	0.92	2.50	0.71
Ability to negotiate terrain obstacles	4.73	0.65	4.18	0.75	3.80	1.14	2.20	0.79
Ability to climb with (traction)	4.73	0.47	3.64	1.21	3.50	1.65	2.10	0.88
Ability to run in snow	4.45	0.69	4.18	0.75	3.70	1.06	1.90	1.20
Ability to drop into prone position	4.73	0.47	4.36	0.67	4.30	0.48	2.60	0.97
Ability to rise from prone position	4.66	0.50	4.18	0.75	4.10	0.32	2.10	0.74

Rating system: Excellent (5) Good (4) Acceptable (3) Marginal (2) Unacceptable (1)

Table 9

Summary of Comments Made on Daily Questionnaires

Snowshoe A
(2) Increase length of tail similar to that of Snowshoe B
(2) Add teeth to frame to assist slope traverse
(3) Binding is not adequate
(4) Heel strap loosens frequently when going down slope
(4) Binding straps are too short
(3) Toe straps too short to grasp when used with VB boot
(1) Strap slipped off toe
(3) Kicks up snow during fast movement
(4) Toe Hole too small when used with vapor barrier boot
(1) Snowshoe of choice
(2) Too small for use in deep powder
(7) Velcro fastener collects snow and ice - loses retention
(3) Maneuverability (trees and terrain obstacles) excellent
(1) Snow buildup on metal plate under boot
(1) Difficult to break trail with

Snowshoe B
(8) Difficult to tie or untie shoelace binding with gloved hands
(4) Shoelaces collect snow and ice
(1) Snowshoe sinks deep in powder snow
(5) Need additional teeth on frame
(5) Snowshoe slides out or skis on slope
(1) Very good climbing slope
(7) Bindings need redesigned
(7) Shoestrings not acceptable
(2) Lower location of heel strap
(2) Snow buildup under foot flap
(1) Noticed lateral movement of heel

Snowshoe C
(4) Snowball-like buildup on crampon
(5) Crampon under ball of foot excellent for climbing slope
(7) Snowshoe slips from under you when traversing across slope
(4) Need teeth or crampon on frame
(7) Snowshoe acts like ski when descending hill
(3) No downhill traction
(2) Laces holding deck to frame look flimsy
(5) Boot in binding unstable on side of slope
(5) Excellent binding and pivot point
(4) Noisy when walking
(1) Heel strap fell off repeatedly
(1) Hard to put on over vapor barrier boot

Snowshoe S
(6) Too heavy
(8) Too large
(3) Awkward, clumsy
(6) Unacceptable for assault
(4) Climbing traction unacceptable - need more teeth
(5) Binding inadequate - needs improved
(3) Maneuverability around trees, obstacles very difficult
(1) Make shorter and lighter
(5) Shovel or toe of snowshoe beats shins (bruised) when running
(3) Snowshoe tails strike your back when falling in prone position

(n) = Number of subjects who made comment.

Table 10

Results of Semantic Differential Rating Scale Questionnaires

Prototype assault snowshoes compared to the standard magnesium snowshoe

Pairs of descriptive phrases	Snowshoe A		Snowshoe B		Snowshoe C	
	mean	SD	mean	SD	mean	SD
Rugged - flimsy	5.00	1.63	4.60	1.65	4.40	2.27
Light - heavy	6.80	0.42	6.50	0.53	6.40	0.70
Narrow - wide	6.10	0.74	6.30	0.48	6.00	0.82
Short - long	6.40	0.70	5.90	0.74	5.70	0.67
Easy - difficult to don	5.30	1.06	4.20	1.87	5.70	1.57
Easy - difficult to doff	5.80	1.40	5.10	1.97	5.30	2.17
Compatible - incompatible with vapor barrier boot	5.00	1.76	5.10	1.85	5.30	2.16
Easy - difficult to adjust binding	5.40	1.43	4.40	2.32	5.60	2.07
Easy - difficult to fasten binding	5.30	1.70	4.00	1.50	5.80	1.99
Binding holds - loses adjustment	4.80	2.04	5.40	2.01	5.90	1.60
Floats on or depresses snow	2.20	1.14	2.40	1.17	3.50	2.01
Easy - difficult to walk in snow	6.70	0.48	6.40	0.70	5.50	2.17
Easy - difficult to maneuver	6.80	0.42	6.30	0.67	5.70	1.16
Easy - difficult to run in snow	6.70	0.48	6.30	0.67	5.10	1.91
Easy - difficult to climb slope	6.50	0.71	4.80	1.55	3.20	2.30
Easy - difficult to negotiate obstacles	6.70	0.48	5.80	1.81	5.00	1.76
Easy - difficult to get into prone position	6.40	0.97	5.90	0.88	5.00	2.26
Easy - difficult to rise from prone position	6.70	0.48	6.10	0.57	5.60	1.65
Response totals	Total	percent	Total	percent	Total	percent
Favorable	152	84.4	138	76.7	140	77.8
Neutral	9	5.0	11	6.1	5	2.8
Unfavorable	19	10.6	31	17.2	35	19.4

A scaled score $\geq$ 5.0 denotes a positive or favorable rating.
A scaled score $\leq$ 3.0 denotes a negative or unfavorable rating.

Table 11

Paired Comparison Incidence Matrix

Snowshoe	A	B	C	S
A	---	3	1	1
B	7	---	3	0
C	9	7	---	4
S	9	10	6	---

Overall System Choice

After the paired comparison booklets were completed, the subjects were asked to turn over the booklets and write the snowshoe they preferred the most. They were instructed that the criterion for their selection was to be based on their snowshoe experiences of this evaluation.

The results determined that 6 of the 10 subjects selected Snowshoe A as their choice. Three subjects selected Snowshoe B, and one selected Snowshoe C. None of the subjects selected the standard snowshoe.

In addition to selecting the overall snowshoe of choice, the subjects were asked to select the snowshoe most preferred during the approach march, for the assault course, for climbing the steep slope, for traversing the slope, and for descending the steep slope. The choices for these selections were collated and are shown in Table 12.

A chi-square statistic was calculated to determine if the marines demonstrated an overall preference for a snowshoe. A chi-square (43.79) was calculated under the null hypothesis of equal preference across all snowshoe types. This statistic was significant at the 0.05 α level and demonstrated that Snowshoe A was preferred in all categories except for the approach march in which Snowshoes A, C, and S were the same.

Table 12

Incidence Matrix for Selections of Choice

Description of choice	Snowshoe A	Snowshoe B	Snowshoe C	Snowshoe S
Overall	6	3	1	0
Approach march	3	0	3	4
Assault course	6	2	2	0
Climbing steep slope	8	0	2	0
Traversing steep slope	7	2	0	1
Descending steep slope	7	1	2	0

Hybrid Snowshoe

After all questionnaires were completed and additional comments made, the subjects were asked to design a hybrid or dream snowshoe. The subjects were instructed to list components that they thought would lead to the design of a hybrid snowshoe, or if one of the snowshoes used in this study was desired, recommend modifications that would optimize the design of the snowshoe. The results were inconclusive because the subjects' opinions for selecting components or suggesting design changes to make the ideal hybrid snowshoe differed greatly. The comments made by each subject are shown in Appendix J.

Compatibility Assessment

The compatibility assessment was conducted to determine if the candidate snowshoes were compatible with any additional cold weather footwear used by the marines. This consisted of a fitting session and mobility trials to assess the compatibility of the snowshoes with the Merrell two-piece ski boots and an abbreviated (because only two subjects owned Alcoe ski boots) fitting session to assess the snowshoe compatibility with the Alcoe single ski boots. The results of the fitting sessions did not reveal problems associated with the fit or adjustment of the snowshoes; however, a compatibility problem was observed when Snowshoe C was worn with either ski boot. The size and shape of the binding were not compatible with those of the square-tipped toe of the ski boots. This shortcoming is discussed in detail in the observations section of this report. No compatibility problems were observed during the mobility trials conducted for the Merrell ski boots.

Durability

No durability problems were observed during this evaluation.

OBSERVATIONS

Human factors and other snowshoe-related observations were made by the experimenters during this evaluation. The following lists were the observations by snowshoe.

Snowshoe A (Atlas)

• The toe hole opening in decking does not fully accommodate larger sizes of vapor barrier boots. The boots rubbed slightly against the edges of the opening.

• The length of the front toe strap is too short to grasp by bare-handed or glove-handed users when worn with vapor barrier boots. Marines used long nose pliers to grasp and pull the strap to adjust it tightly (see Figure K-1 in Appendix K).

• The hook and pile closure on the largest toe strap collects ice and snow (see Figure K-2). This lessens retention capabilities of the closure and makes it difficult to refasten when readjustment or refastening is required.

• The snowshoes tend to ski or slip out from under the user when he traverses steep slopes (see Figure K-3).

• The heel adjustment strap slips in the buckle and loses retention during steep slope descent. A loosened strap that was observed after the subject descended the slope is shown in Figure K-4.

• The snowshoes kicked up snow, creating the billowy cloud of snow that is present around the marine shown in Figure K-5. This effect occurred when the marines ran the assault course.

Snowshoe B (Redfeather)

• The design of the binding used on this snowshoe required users to interlace shoestrings through eyelets, pull the strings to adjust the tightness, and then tie a bow knot in the string to secure the closure. Consequently, it took significantly longer to don this snowshoe when bare handed and was nearly impossible and very time consuming to fasten when glove handed. It was noted that the laces occasionally became tightly knotted and were difficult to unfasten when bare handed. This type closure is not acceptable for use in snowshoe environments.

• The snowshoes skied or slipped out from under the user when he traversed and descended the steep slope.

• The snowshoes kicked up snow, creating a billowy cloud of snow behind and to the side of the user when he ran the course (see Figures K-5 and K-6).

• The fasteners that mount and hold the binding and crampon between the upper and lower crossbar tended to loosen. On one occasion, the round head machine screw unthreaded itself from the pronged tee nut (threaded wood insert) and was lost. This permitted lateral movement of the binding (and user's foot) on the snowshoe, rendering it ineffective and difficult to use. Periodic inspections of the snowshoes revealed that these fasteners often needed to be retightened.

Snowshoe C (Tubbs)

• The toe hole opening in decking did not fully accommodate larger sizes of vapor barrier boots. The foremost portion of the binding and the sides of the vapor barrier boots rub against the edges of the toe hole. The rubbing effect creates a loud clicking sound. The sound level increases as the temperature of the snowshoe materials decreases. The marines stated that the clicking noise produced an easily detectable signature.

• The shape and opening (see arrows in Figure K-7) of the foremost portion of the binding was designed to center the front of a user's boot and cradle his forefoot in the proper position. This feature worked adequately with the vapor barrier boot but was not compatible with the size and shape of the ski boots with the NATO 75-mm square-tipped toe. The shape and opening of this portion of the binding did not conform to the shape and size of the toe area of the ski boots. The automatic centering feature of the binding is negated unless the toe of the boot fits into the toe opening of the binding.

• The snowshoes skied or slipped out from under the user when he traversed the steep slope. Some subjects stated that this shoe had a great tendency to ski when descending the slope.

• The snowshoes accumulated a significant amount of snow under the ball of the foot as shown in Figure K-8. The metal portion of the binding and the crampon is exposed (see Figure C-1). Since metal materials are wettable, they inherently attract snow and ice. The square shape and the angularities of the crampon may also aid in snow accumulation. Figures K-9 and K-10 are photographs of the bottoms of the other snowshoes. Note that the crampon areas on these snowshoes had little or no snow accumulation.

Snowshoe S (Standard Military-Trail Magnesium)

• The size and shape of the snowshoes required the marines to alter their gait when walking and running. They required the user to walk and run in a bowlegged fashion so that he would not step on and trip over his own snowshoes.

• On at least five occasions, the bindings loosened and one of the snowshoes fell completely off the user's foot (see Figure K-11) when he ran the assault course. These snowshoes sometimes fell off the user's foot while he was getting into or out of the prone firing position (see Figure K-12). The subjects also stated that the bindings required frequent retightening.

• When the marines ran the assault course wearing these snowshoes, two serious interactions occurred between the user and the snowshoe. The prominent upturn in the toe of the snowshoe battered the users' shins causing serious bruising of the shins. Many users stuffed padding (extra clothing items) into the lower portion of their trousers to protect their shins. It was also noted that the tail of the snowshoe struck against the users' backs when they got into the prone firing position.

DISCUSSION

The three candidate snowshoes evaluated during this study were off-the-shelf commercially available items designed for recreational use by hikers and back packers. MARCORSYSCOM's selection of these particular snowshoes was based on a general criterion of design characteristics thought to be desirable in an assault snowshoe. Since the size and weight of the current snowshoe were thought to be the primary cause of the mobility and agility problem, lighter and smaller candidates were chosen. In addition, the three candidates were selected because they appeared to be durable and their bindings appeared to be compatible with marine cold weather footwear.

As might be expected when a commercially available item is used with military equipment, some compatibility problems were observed during this study. None excluded the use of a particular candidate snowshoe. Most of the problems had to do with the bindings and were caused by the size of the vapor barrier boot and the toe of the ski march boot. Obviously, the bindings on the candidate snowshoes were designed to fit over hiking boots and other footwear typically worn by civilians but not over ski march and vapor barrier boots. The size of the vapor barrier boot made it difficult to grasp and pull

tight the toe strap on the "A" snowshoe bindings because the strap had to be fully extended to accommodate the vapor barrier boot. In this study, most the marines had to grasp the strap with pliers to tighten the toe binding.

The objective results from this study determined that the marines were able to run a short assault course and get into and out of a prone position more rapidly with the candidate snowshoes than with the standard military snowshoes. The difficulty that the marines had running in the standard snowshoe was easy to see (and hear) because they had to run with their legs (thus feet and snowshoes) spread apart in an effort to allow for the size of the snowshoes. Often, they failed to do this adequately and tripped as they stepped on their own snowshoes or struck their shins with the snowshoes while running.

One of the reported problems with the standard snowshoe was that its size and length made it difficult to get into and out of a prone position. In this study, the time required to get into and out of the prone position was significantly slower only at the 25-meter pole position. Surprisingly, the mean difference was less than a second. Possibly, the more experienced marines participating in this study had learned to allow for the size of the snowshoe while performing this task.

As was expected, flotation for the larger standard snowshoe was rated higher than the smaller prototype snowshoes but not significantly so. These results may have been different if lighter and deeper snow had been encountered and/or the body weight of the individual and his load had been greater. The brevity of the cross-country march did not lend itself to determining the effects of sustained use. For instance, greater levels of fatigue may be experienced when a snowshoe with less flotation is worn over a longer period of time. The concept used in developing the scenarios for this evaluation was that marines ski to a point close to their objective, doff their skis and existence load, don the assault snowshoes and make an assault with a combat load. The inclusion of a short cross-country march in this study was an effort to provide the subjects with some sustained wear experience. This task did provide the subjects with some cross-country movement experience, but the movement was not of sufficient length to draw conclusions regarding fatigue and other effects that might be attributable to reduced flotation. It did provide the subjects with some limited experience in bridging and walking around natural obstacles and an opportunity to gain more experience on the snowshoes before completing the questionnaires.

CONCLUSIONS

1. Marines negotiated an assault course significantly faster with the assault snowshoe candidates than when using the military standard snowshoe.

2. Marines got into and out of a prone firing position significantly faster when using the assault snowshoe candidates than when using the military standard snowshoe.

3. Marines could don Snowshoe C faster than the other snowshoes. Marines could don Snowshoes A and C significantly faster than they could don Snowshoe B when bare handed. Marines could don Snowshoes C, S, and A significantly faster than they could Snowshoe B when glove handed. Snowshoe C was significantly better than A for the glove-handed trials. Snowshoe B was considered much more difficult to don.

4. None of the snowshoes were difficult to doff.

5. The toe holes in the decking of Snowshoes A and C were not fully compatible with the vapor barrier boot nor was the length of the front toe strap of Snowshoe A. The foremost portion of the binding of Snowshoe C was not compatible with the size and shape of the ski boots with the NATO 75-mm square-tipped toe. The shoestring closure that adjusts tightly and secures the binding on Snowshoe B is nearly impossible to grasp and pull tight while wearing gloves.

6. All the assault snowshoe candidates were rated highly. No statistical differences were noted among the snowshoes for paired comparisons, but the subjective ratings and overall selections of choice indicate that the majority preferred Snowshoe A. The ratings also suggest that the standard military snowshoe is unacceptable for use during an assault.

7. None of the candidate snowshoes evaluated are acceptable for military usage without implementing some design changes to correct the shortcomings noted in this report.

8. No durability problems were observed during this evaluation.

RECOMMENDATIONS

All the assault snowshoe candidates evaluated require design modifications to be compatible with cold weather footwear used by the military. To optimize the effectiveness of these snowshoes, they should be modified to correct for the design and shortcomings that were observed and reported. Recommendations for each candidate snowshoe are as follow:

Snowshoe A (Atlas)

1. Increase frame width (possibly 1 inch) to improve flotation characteristics and to permit enlargement of the toe hole opening to accommodate various sizes of vapor barrier boots.

2. Add gripper teeth to sides of frame to improve traction when a user traverses slopes.

3. Lengthen front toe strap so that a user wearing vapor barrier boots can grasp and pull the strap tight.

4. Change fastener on largest toe strap to a strap and buckle fastener. The current hook and pile fastener collects snow and ice, which lessens retention and makes it more difficult to refasten when adjustment is required.

5. Increase the thickness of the ankle strap to improve retention between the strap and buckle. The strap slips in the buckle and loses retention during descent of steep slopes.

Snowshoe B (Redfeather)

1. Add gripper teeth to sides of frame to improve traction when a user traverses slopes.

2. Add chevron-shaped crampon to the rear of snowshoe decking to provide traction when a user descends steep slopes.

3. Improve retention capabilities of round head machine screw and threaded insert used to mount the binding and crampon between the upper and lower neoprene crossbar. A nylon locking thread insert may prevent the screw from unthreading itself.

4. Redesign the closure used for this binding. It was nearly impossible and very time consuming to fasten and unfasten the shoelaced closure when the users wore gloves.

Snowshoe C (Tubbs)

1. Add gripper teeth to side of frame to improve traction when a user traverses slopes.

2. Add chevron-shaped crampon to rear decking to improve traction when a user descends steep slopes.

3. Enlarge the toe hole opening to accommodate the size of the vapor barrier boot. (The toe portion of the binding and the sides of the boot rub against the edges of the toe hole, creating a loud clicking sound when the user walks.)

4. Redesign the size and shape of the toe portion of the binding to accommodate the NATO ski boot (75-mm squared-tipped toe) as well as the vapor barrier boot. The width of the toe portion of the binding and its opening is not compatible with the square toe area of the ski boot.

5. The frame width at the toe hole opening may have to be widened to accommodate a wider binding and toe hole opening as discussed.

6. Insulate the metal support bracket on the bottom of the binding with rubber or plastic. These materials are not as wettable and may prevent snow from accumulating on the crampon and its surrounding area.

APPENDIX A

VOLUNTEER AGREEMENT AFFIDAVIT

VOLUNTEER AGREEMENT AFFIDAVIT

For use of this form, see AR 70-25; the proponent agency is OTSG

PRIVACY ACT OF 1974

Authority: 10 USC 3013, 44 USC 3101, and 10 USC 1071-1087.

Principle Purpose: To document voluntary participation in the Clinical Investigation and Research Program. SSN and home address will be used for identification and locating purposes.

Routine Uses: The SSN and home address will be used for identification and locating purposes. Information derived from the study will be used to document the study; implementation of medical programs; adjudication of claims; and for the mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State and local agencies.

Disclosure: The furnishing of your SSN and home address is mandatory and necessary to provide identification and to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in this investigational study.

PART A(1) - VOLUNTEER AFFIDAVIT

Volunteer Subjects in Approved Department of the Army Research Studies

Volunteers under the provisions of AR 40-38 and AR 70-25 are authorized all necessary medical care for injury or disease which is the proximate result of their participation in such studies.

I, ______________________________, SSN ______________,

having full capacity to consent and having attained my __________ birthday, do hereby volunteer/give consent as legal

representative for ______________________________ to participate in Mobility

Human Factors Evaluation of Three Prototype Assault Snowshoes.

(Research study)

under the direction of William E. Hanlon and Charles A. Hickey

conducted at U.S. Marine Corps Mountain Warfare Training Center, Bridgeport, CA.

(Name of Institution)

The implications of my voluntary participation/consent as legal representative; duration and purpose of the research study; the methods and means by which it is to be conducted; and the inconveniences and hazards that may reasonably be expected have been explained to me by

____

I have been given an opportunity to ask questions concerning this investigational study. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights/the rights of the person I represent on study-related injury, I may contact

Chief Medical Officer

at U.S. Marine Corps Mountain Warfare Training Center, Bridgeport, CA

(Name, Address and Phone Number of Hospital (Include Area Code))

I understand that I may at any time during the course of this study revoke my consent and withdraw/have the person I represent withdrawn from the study without further penalty or loss of benefits; however, I/the person I represent may be required (military volunteer) or requested (civilian volunteer) to undergo certain examination if, in the opinion of the attending physician, such examinations are necessary for my/the person I represent's health and well-being. My/the person I represent's refusal to participate will involve no penalty or loss of benefits to which I am/the person I represent is otherwise entitled.

____

PART A (2) - ASSENT VOLUNTEER AFFIDAVIT *(MINOR CHILD)*

I, ______________________________, SSN ______________ having full

capacity to consent and having attained my __________ birthday, do hereby volunteer for ______________

______________________________ to participate in ______________________________

____

(Research Study)

____

under the direction of ______________________________

conducted at ______________________________.

(Name of Institution)

(Continue on Reverse)

DA FORM 5303-R, MAY 88 | PREVIOUS EDITIONS ARE OBSOLETE

PART A(2) - ASSENT VOLUNTEER AFFIDAVIT (*MINOR CHILD*) *(Cont'd.)*

The implications of my voluntary participation; the nature, duration and purpose of the research study; the methods and means by which it is to be conducted; and the inconveniences and hazards that may reasonably be expected have been explained to me by

____

I have been given an opportunity to ask questions concerning this investigational study. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights I may contact

____

at ______________________________
(Name, Address, and Phone Number of Hospital (Include Area Code))

I understand that I may at any time during the course of this study revoke my assent and withdraw from the study without further penalty or loss of benefits; however, I may be requested to undergo certain examination if, in the opinion of the attending physician, such examinations are necessary for my health and well-being. My refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled.

____

PART B - TO BE COMPLETED BY INVESTIGATOR

INSTRUCTIONS FOR ELEMENTS OF INFORMED CONSENT: *(Provide a detailed explanation in accordance with Appendix E, AR 40-38 or AR 70-25.)*

SEE ATTACHED.

I do ☐ *do not* ☐ *(check one & initial)* consent to the inclusion of this form in my outpatient medical treatment record.

SIGNATURE OF VOLUNTEER	DATE	SIGNATURE OF LEGAL GUARDIAN *(If volunteer is a minor)*	
PERMANENT ADDRESS OF VOLUNTEER	TYPED NAME OF WITNESS		
	SIGNATURE OF WITNESS		DATE

REVERSE OF DA FORM 5303-R, MAY 88

Mobility and Human Factors Evaluation of
Three Prototype Assault Snowshoes

Part B

You were given a pretest briefing where the objectives of the mobility and human factors evaluation of prototype assault snowshoes was explained to you. In addition, you were briefed on your involvement in this evaluation. Afterwards, you were given the opportunity to ask questions that are relative to your participation in the conduct of this test. These questions were answered to your satisfaction before you volunteered to participate.

To reiterate, this evaluation will be conducted to determine if any of the prototype snowshoes will make you more agile and enhance your ability to maneuver rapidly during an assault; and to determine the user acceptance (human factors issues) of each type of snowshoe. The mobility portion of this evaluation will be conducted on courses located at the Mountain Warfare training Center. Some of the human factors issues will be addressed during the mobility scenarios and some may be addressed at the base camp at the end of the mobility trials.

Since you are a volunteer participant, it is a requirement that your medical records are reviewed prior to your participation. This review will be conducted by a medical officer at the Mountain Warfare Training Center. This review is necessary to assure that you do not have a history of cold intolerance or injuries that would prevent you to safely participate in this evaluation.

The mobility portion of this evaluation will require you to conduct eight mobility scenarios over a four day period. You will be required to negotiate various mobility courses with an assault load. This load consists of clothing and equipment items (listed in Table A1) that you will wear or carry during each scenario. The total weight of the load is approximately 57 pounds.

During each mobility test day you will be required to negotiate a 2500 meter cross-country course, a 75 meter assault course, and a 150 meter steep slope course in the morning and again in the afternoon (twice per day). Adequate rest periods (about 15 min.) will be given after each event and a lunch break between the morning and afternoon trials.

The 2500 meter cross-country course will be a self paced course through wooded terrain. Its purpose is to force you to maneuver over and around fallen and standing trees, up and down gullies or trenches, and to negotiate any natural terrain obstacles you may encounter. This course will provide you with an introductory period of use upon which can be used to form opinions for the subjective ratings you will make.

The 75 meter assault course will be negotiated or traversed as fast as you can. At 25 and 50 meters into the course you will be required to drop into a prone position, simulate firing at a target, and rise from the prone position and continue the course. The total time required for you to negotiate this course will be recorded. In addition to the objective data taken, you will be able to form opinions about getting into and rising from the prone position and about the maneuverability characteristics of the snowshoes.

The 50 meter steep sloped course will be traversed as fast as you safely can. The times required for you to climb and descend from the slope will be recorded. This course will enable you to form opinions about the climbing characteristics of the snowshoes.

After the completion of the mobility scenarios each day, you will be asked to participate in donning and doffing trials. The times required for you to put on and take off the snowshoes that you used that day will be recorded.

At the end of each test day, you will be assembled in a debriefing room and asked to fill out questionnaires pertaining to the snowshoe you wore. You will also be asked to participate in a structured debriefing session where you will be encouraged to express you opinions (favorable and unfavorable) about the snowshoes worn.

After the mobility portion of the evaluation is completed, some of you will be asked to participate in the compatibility assessment. The objective here is to see if various marine corps cold weather footwear is compatible with the snowshoes and to see if the snowshoes can be easily stowed on a pack rigged for a sustainment march.

After the evaluation is completed, you will be required to fill out post-test questionnaires in which you will rate features and characteristics of each snowshoe. You will also be given a questionnaire that will require you to compare the snowshoes with one another and you will be asked to select the snowshoe of your choice.

If you sustain a medical injure (i.e., turn an ankle) during this evaluation you will be taken to the training center medical facility via the safest means possible.

You will receive no direct benefits from your participation in this study other than the knowledge and experience you may gain. However, the results of these tests may help the USMC in the selection of a snowshoe that would enhance performance of marines during an assault.

All data and medical information obtained about you as an individual will be considered privileged and held in confidence. Complete confidentiality can not be promised because information bearing on your health may be required to be reported to appropriate medical or command authorities.

The results of these tests will be confidential; that is, your identities will not be associated with published test results. You have the right of access to any of the data collected on you. Any questions about this data should be addressed to the test director, Mr. William E. Hanlon, DSN 298-5920 or 410-278-5929.

Table A-1

Clothing and Equipment Items

Clothing and equipment items	Weight (lb)
Clothing	
Polypropylene underpants	0.82
Polypropylene undershirt	0.68
Polypropylene liner sock	0.10
Wool-polypropylene insulating sock	0.23
Polyester fiberpile jacket	1.30
Extended cold weather clothing system (ECWCS) polytetrafluorethylene (PTFE) parka with hood	1.85
ECWCS PTFE trouser	1.04
Trigger finger mitten with wool inserts	0.81
Extreme cold weather boot, white insulated	6.20
Equipment	
Assault pack (containing clothing, equipment, rations)	20.00
Individual equipment belt	0.86
Individual equipment suspenders	0.64
Canteen, cup, cover w/quart water (two each)	6.64
Ammunition pouches w/30-round magazines (two each)	7.14
First aid kit	1.17
M16A2 rifle	7.20
Total assault load weight	56.68

Note. Weights differ from those in Table 1 because the loads were modified for the actual test. Some items were eliminated, and therefore, loads in Table 1 are lighter than those shown here.

APPENDIX B

ANTHROPOMETRIC MEASURES AND BOOT SIZE OF SUBJECTS

ANTHROPOMETRIC MEASURES AND BOOT SIZE OF SUBJECTS

Table B-1

Anthropometric Body Measures and Boot size of Subject Group

Subject ID No.	Inches	Stature percentile USMC-77	Stature percentile ANSUR 88	Pounds	Weight percentile USMC-77	Weight percentile ANSUR 88	Boot
1	72	90th	86th	165	67th	40th	9.5R
2	73.5	97th	95th	179	85th	62th	10.5R
3	72.5	93rd	90th	178	82th	61st	.5R
4	70	70th	63rd	207	98th	91st	11R
5	74	98th	97th	215	99th	94th	10W
7	66	15th	12th	170	72nd	48th	9W
8	74	98th	97th	206	98th	90th	11R
9	74	98th	97th	208	98th	91th	12R
10	70	70th	63rd	150	37th	17th	8N
11	69	55th	49th	170	72nd	48th	9W
12	71	81st	76th	192	94th	79th	9.5W

Percentile values from 1977 USMC Anthropometric Survey and the 1988 Army Survey (ANSUR 88).

Table B-2

Summary Statistics for Subject Group (N=11)

Statistic	Stature	Weight
Subject group mean	71.45	185.45
Subject group SD	2.55	21.36
Group percentile (compared to USMC-77	86th	89th
Group percentile (compared to ANSUR 88)	81st	71st
USMC 1977 survey mean	68.72	160.16
Army 1988 survey mean	69.13	173.03

This subject group was taller and heavier than the USMC population in 1977 survey and the Army population in 1988 survey.

APPENDIX C

PHOTOGRAPHS OF CANDIDATE SNOWSHOES

PHOTOGRAPHS OF CANDIDATE SNOWSHOES

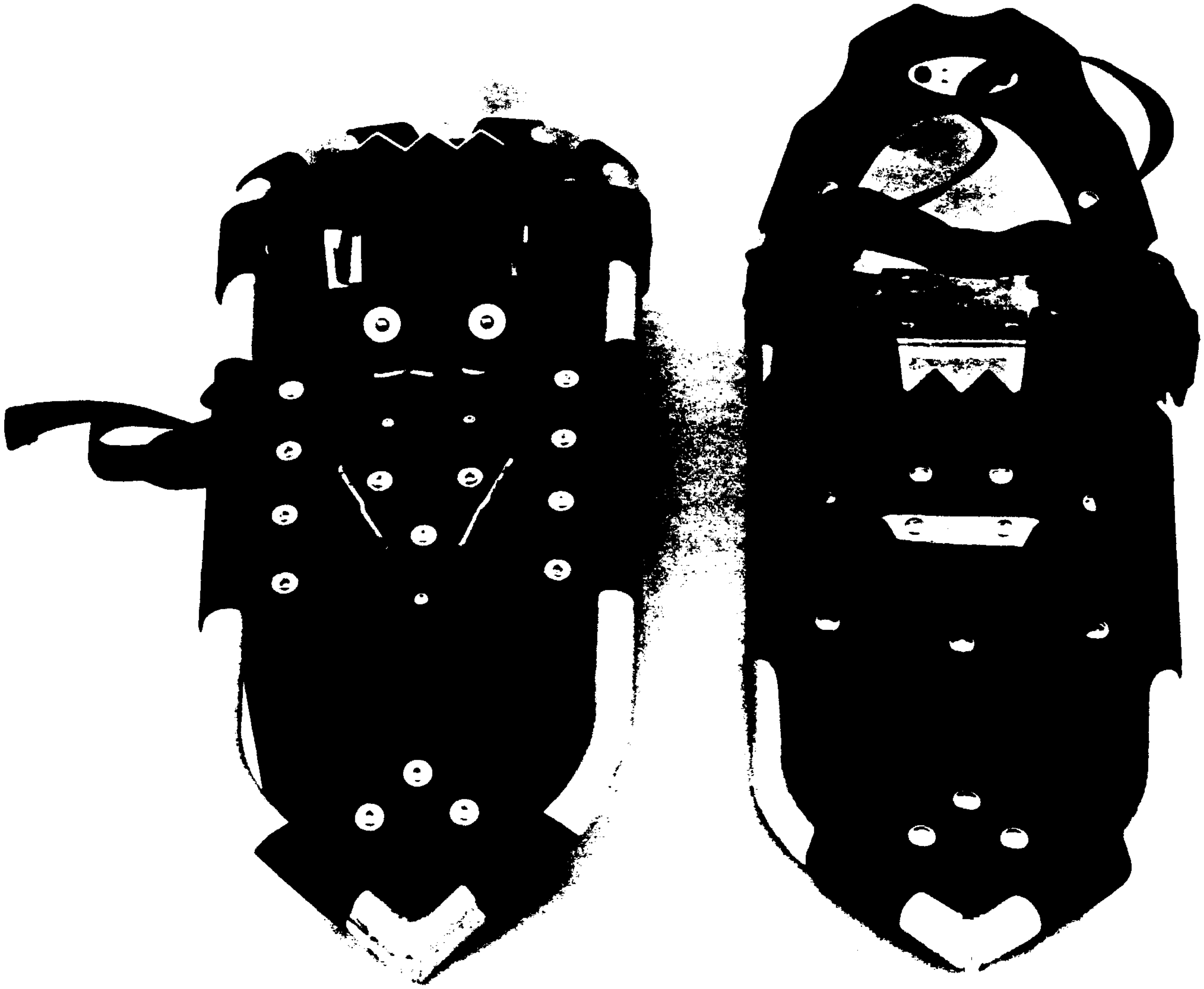

Figure C-1. Snowshoe A - Atlas model 1022.

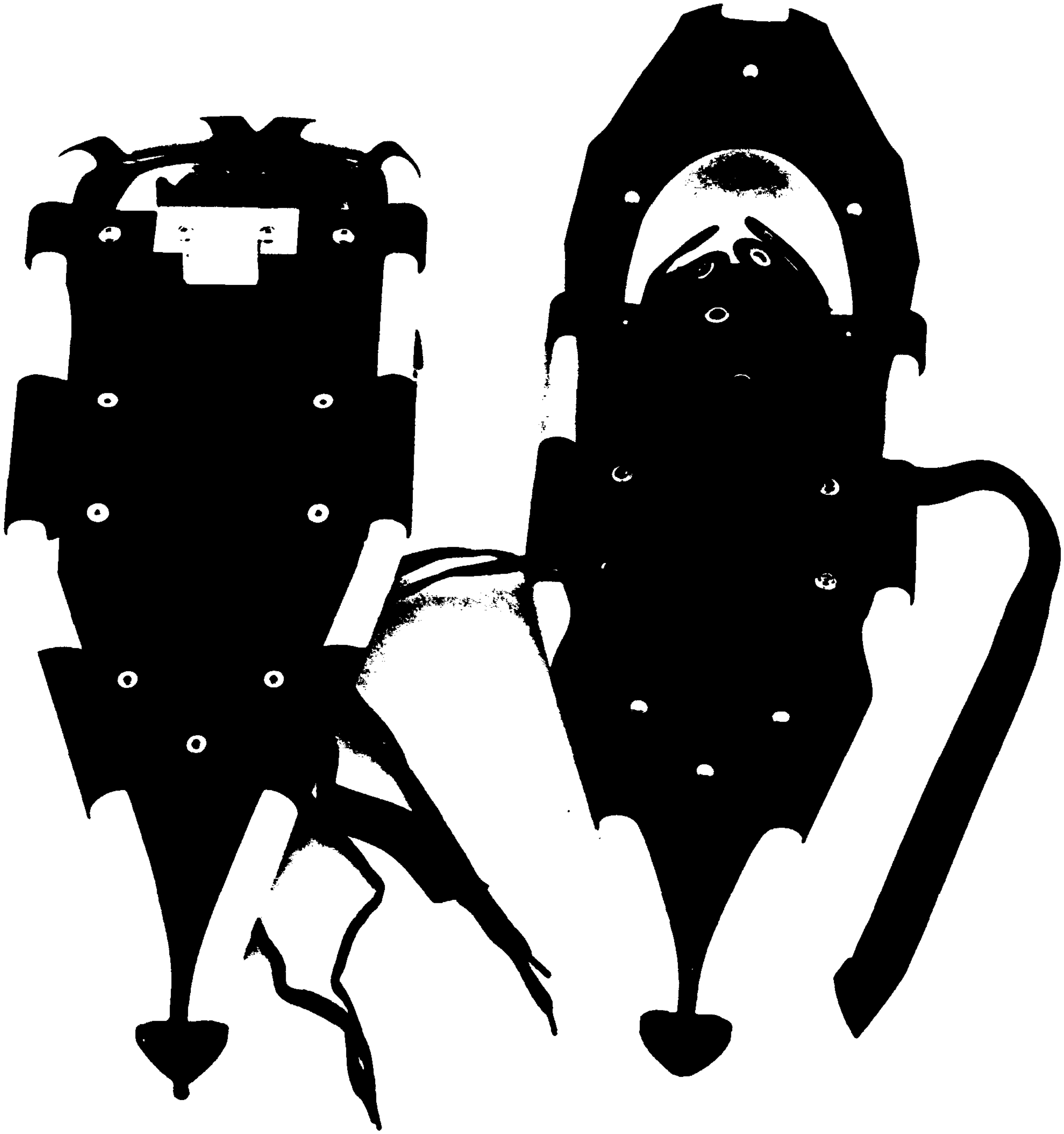

Figure C-2. Snowshoe B - Redfeather model harrier.

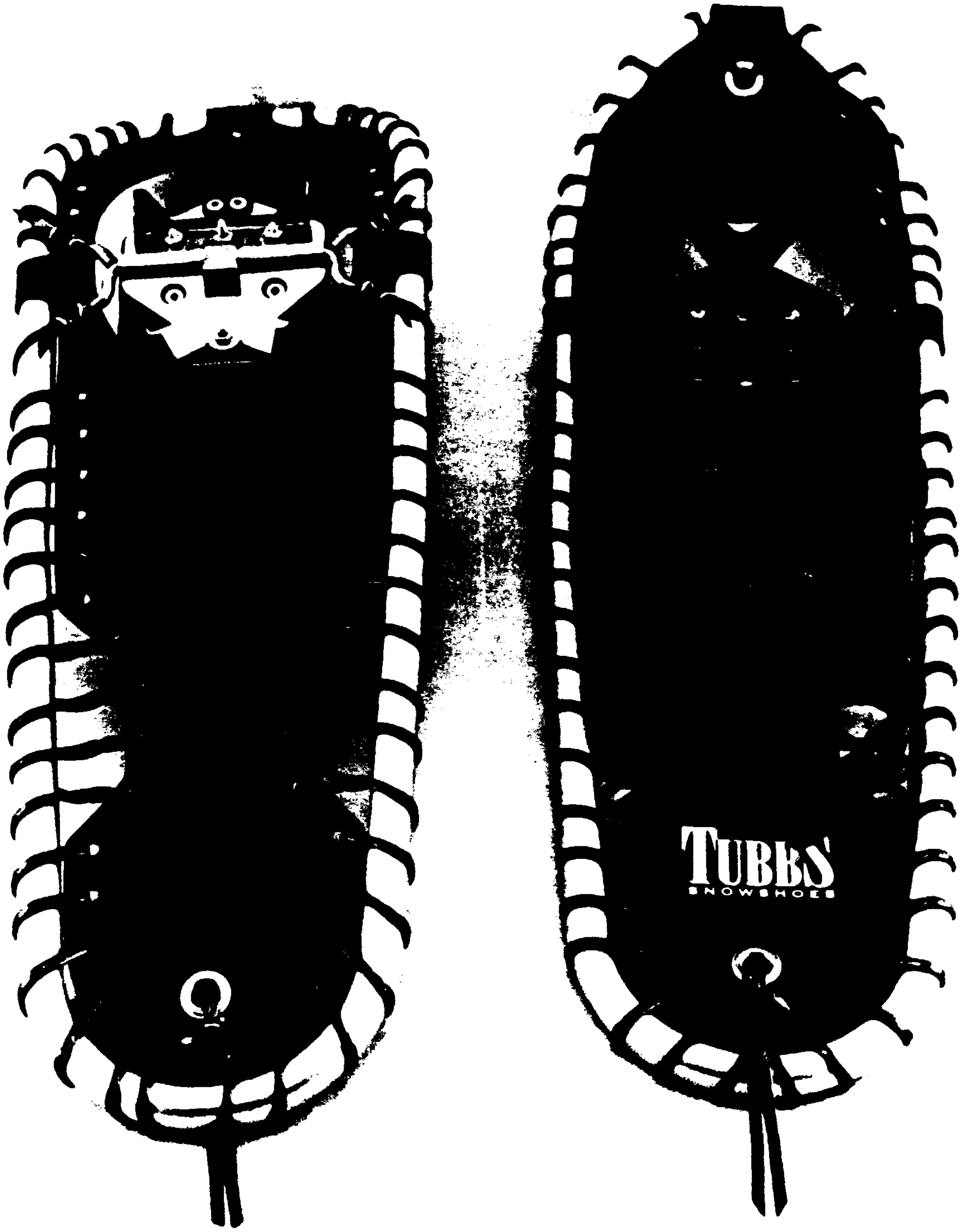

Figure C-3. Snowshoe C - Tubbs model katahdin.

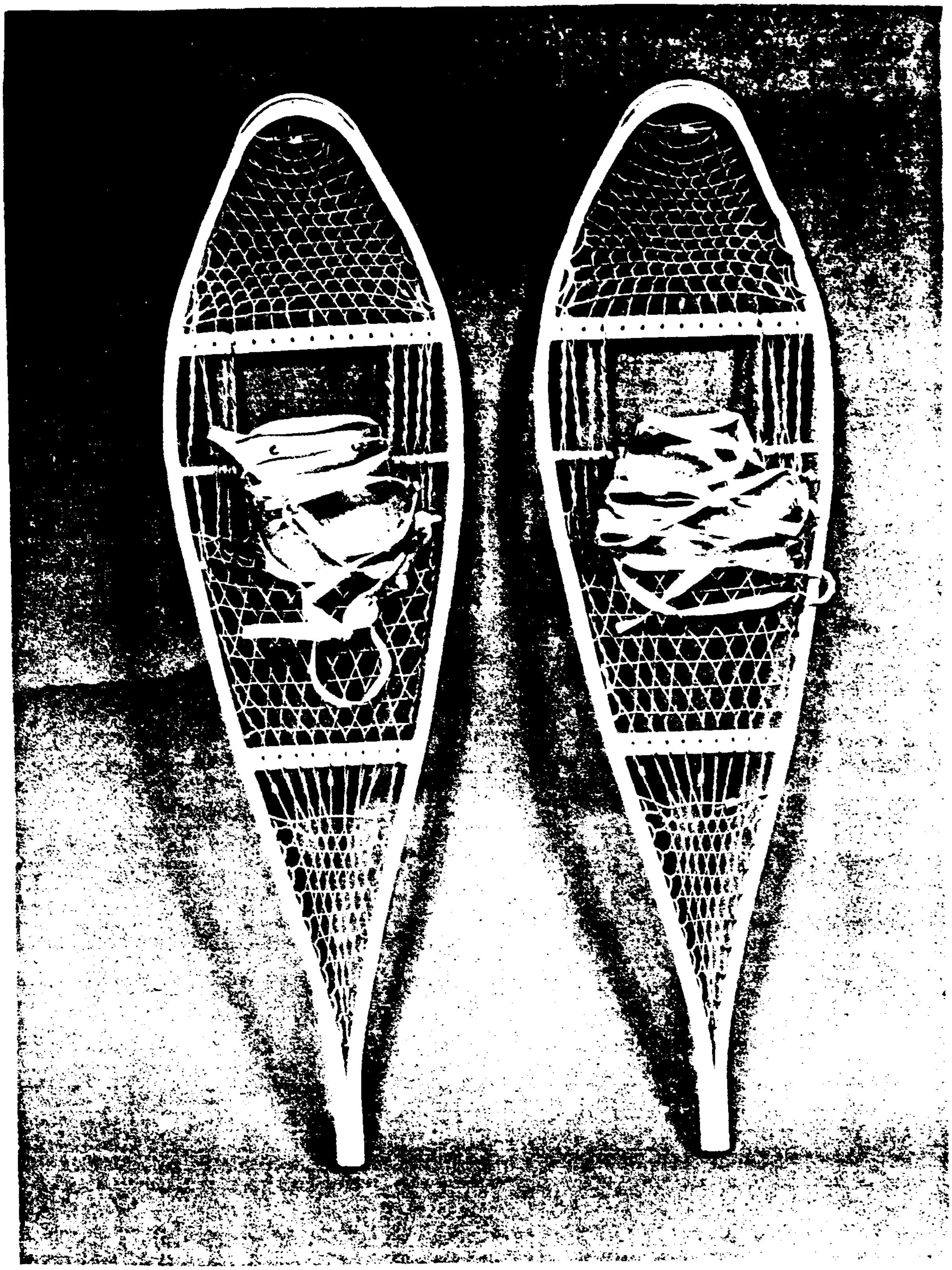

Figure C-4. Snowshoe S - standard trail magnesium.

APPENDIX D

POSTTEST QUESTIONNAIRES

POSTTEST QUESTIONNAIRES

DAILY RATING QUESTIONNAIRE

Name ______________________________ ☐ Wet Snow

Subject No. ________ ☐ Hard Crusted Snow

Circle Snowshoe Used: A B C S ☐ Dry Powdery Snow

Mobility Ratings	Excellent	Good	Acceptable	Marginal	Unacceptable
Ruggedness	☐	☐	☐	☐	☐
Overall Size	☐	☐	☐	☐	☐
Weight	☐	☐	☐	☐	☐
Width	☐	☐	☐	☐	☐
Length	☐	☐	☐	☐	☐
Fit	☐	☐	☐	☐	☐
Ease of Use	☐	☐	☐	☐	☐
Ease of Putting On	☐	☐	☐	☐	☐
Ease of Adjusting Binding Strap	☐	☐	☐	☐	☐
Stability of Boot in Binding	☐	☐	☐	☐	☐
Size of Toe Hole	☐	☐	☐	☐	☐
Compatibility with Vapor Barrier Boot	☐	☐	☐	☐	☐
Retention Capability of Binding Straps	☐	☐	☐	☐	☐
Ease of Taking Off	☐	☐	☐	☐	☐
Ability to Stay Afloat on Snow	☐	☐	☐	☐	☐
Ability to Walk in Snow	☐	☐	☐	☐	☐
Ability to Maneuver	☐	☐	☐	☐	☐
Ability to Negotiate Terrain Obstacles	☐	☐	☐	☐	☐
Ability to Climb With (Traction)	☐	☐	☐	☐	☐
Ability to Run in Snow	☐	☐	☐	☐	☐
Ability to Drop into Prone Position	☐	☐	☐	☐	☐
Ability to Rise from Prone Position	☐	☐	☐	☐	☐

SEMANTIC PROFILE QUESTIONNAIRE

Subject No._____ Circle Snowshoe Type A B C

Directions: Express your opinion of the snowshoe you are rating along the seven point scale for each pair of words or phrases. Consider the standard snowshoe (midpoint of scale) as the basis for comparison. Use the modifiers extremely, moderately, or slightly to best describe your opinion for each rating.

	Extremely	Moderately	Slightly	Same as Standard Snowshoe	Slightly	Moderately	Extremely	
Rugged	O	O	O	O	O	O	O	Flimsy
Heavy	O	O	O	O	O	O	O	Light
Narrow	O	O	O	O	O	O	O	Wide
Short	O	O	O	O	O	O	O	Long
Hard To Put On	O	O	O	O	O	O	O	Easy To Put On
Easy To Take Off	O	O	O	O	O	O	O	Hard To Take Off
Incompatible With Boots	O	O	O	O	O	O	O	Compatible With Boots
Easy To Adjust Binding	O	O	O	O	O	O	O	Hard To Adjust Binding
Hard To Fasten Binding	O	O	O	O	O	O	O	Easy To Fasten Binding
Binding Holds Adjustment	O	O	O	O	O	O	O	Binding Looses Adjustment
Sinks In Snow	O	O	O	O	O	O	O	Floats On Snow
Easy To Walk With	O	O	O	O	O	O	O	Hard To Walk With
Hard To Maneuver	O	O	O	O	O	O	O	Easy To Maneuver
Easy To Run With	O	O	O	O	O	O	O	Hard To Run With
Hard To Climb With	O	O	O	O	O	O	O	Easy To Climb With
Easy To Negotiate Obstacles	O	O	O	O	O	O	O	Hard To Negotiate Obstacles
Hard To Get Into Prone Pos.	O	O	O	O	O	O	O	Easy To Get Into Prone Pos.
Easy To Rise From Prone Pos.	O	O	O	O	O	O	O	Hard To Rise From Prone Pos.

PAIRED HEAD TO HEAD COMPARISONS

Subject No.______

Directions: On each page of this booklet, you are to circle the snowshoe that you most preferred and then select the one box that best represents the reason for your choice. Make one choice for each page. Do not look back at previous choices. An example follows:

MITTENS vs GLOVES

- ❒ Shape
- ❒ Weight
- ❒ Warmth
- ❒ Dexterity

If the mittens and gloves had identical materials and insulation, I would choose mittens because I feel they are warmer than gloves.

A vs B

- ❐ Weight
- ❐ Size or Shape
- ❐ Flotation Features
- ❐ Tracking Features
- ❐ Traction Features
- ❐ Enhanced Maneuverability

B vs C

- Weight
- Size or Shape
- Flotation Features
- Tracking Features
- Traction Features
- Enhanced Maneuverability

C vs Std

- Weight
- Size or Shape
- Flotation Features
- Tracking Features
- Traction Features
- Enhanced Maneuverability

Std vs A

- ❐ Weight
- ❐ Size or Shape
- ❐ Flotation Features
- ❐ Tracking Features
- ❐ Traction Features
- ❐ Enhanced Maneuverability

B VS Std

- Weight
- Size or Shape
- Flotation Features
- Tracking Features
- Traction Features
- Enhanced Maneuverability

A vs C

- ❑ Weight
- ❑ Size or Shape
- ❑ Flotation Features
- ❑ Tracking Features
- ❑ Traction Features
- ❑ Enhanced Maneuverability

APPENDIX E

REGRESSION ANALYSES

```
                    * * * *   M U L T I P L E   R E G R E S S I O N   * * * *

Listwise Deletion of Missing Data

Equation Number 1    Dependent Variable..   DEPTH    Snow depth-inches

Block Number  1.  Method:  Forward      Criterion    PIN   .0500

Variable(s) Entered on Step Number  1..     MEASURE    Snow-gage device

Multiple R           .90220          Analysis of Variance
R Square             .81397                               DF      Sum of Squares      Mean Square
Adjusted R Square    .81170          Regression            1          1197.43966       1197.43966
Standard Error      1.82686          Residual             82           273.66971          3.33744

                                     F =       358.79036       Signif F =  .0000

------------------ Variables in the Equation ------------------    ------------- Variables not in the Equation -------------

Variable              B          SE B        Beta         T  Sig T    Variable     Beta In  Partial  Min Toler        T  Sig T

MEASURE        1.419661       .074949     .902203    18.942  .0000    TP           .017896  .041420    .996544      .373  .7100
(Constant)      .285757       .522654                  .547  .5860    WEIGHT       .064005  .148308    .998818     1.350  .1809
                                                                      SNOWSHOE    -.177350 -.410979    .998981    -4.057  .0001

                     * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

Variable(s) Entered on Step Number  2..     SNOWSHOE   Snowshoe type

Multiple R           .91945          Analysis of Variance
R Square             .84539                               DF      Sum of Squares      Mean Square
Adjusted R Square    .84157          Regression            2          1243.66351        621.83175
Standard Error      1.67570          Residual             81           227.44587          2.80797

                                     F =       221.45213       Signif F =  .0000

------------------ Variables in the Equation ------------------    ------------- Variables not in the Equation -------------

Variable              B          SE B        Beta         T  Sig T    Variable     Beta In  Partial  Min Toler        T  Sig T

MEASURE        1.410754       .068782     .896543    20.510  .0000    TP           .007369  .018675    .993024      .167  .8677
SNOWSHOE       -.664437       .163764    -.177350    -4.057  .0001    WEIGHT       .070247  .178440    .997614     1.622  .1087
(Constant)     1.972627       .634578                 3.109  .0026
```

```
                    * * * *   M U L T I P L E   R E G R E S S I O N   * * * *

Equation Number 1    Dependent Variable..   DEPTH   Snow depth-inches

End Block Number   1   PIN =     .050 Limits reached.
```

APPENDIX F

ANOVA OF SNOWSHOE FLOTATION MEASUREMENTS

ANOVA OF SNOWSHOE FLOTATION MEASUREMENTS

ANALYSIS OF VARIANCE

Test of Signficance for FLOTATION using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Error 1	155.56	27	5.76		
REGRESSION	1151.73	1	1151.73	199.91	0.000
SNOWSHOE	45.97	3	15.32	2.66	0.068

ANALYSIS OF VARIANCE

Regression Analysis for Error 1 error term
Dependent Variable.. FLOTATION

COVARIATE	B	Beta	Std. Err.	t-Value	Sig t	Lower-95	CL-Upper
Measure	1.45852	.93862	.10316	14.13885	0.000	1.24686	1.67019

APPENDIX G

ANOVA OF ASSAULT COURSE AND PRONE FIRING POSITION TIMES

ANOVA OF ASSAULT COURSE AND PRONE FIRING POSITION TIMES

ANALYSIS OF VARIANCE

Tests of Signficance for ASSAULT COURSE TIME using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Error 1	838.29	27	31.05		
REGRESSION	894.05	1	894.05	28.80	0.000
SNOWSHOE	664.38	3	221.46	7.13	0.001

ANALYSIS OF VARIANCE

Regression Analysis for Error 1 error term
Dependent Variable.. ASSAULT COURSE TIME

COVARIATE	B	Beta	Std. Err.	t-Value	Sig t	Lower-95%	CL-Upper
MEASURE	1.28504	.71840	.23947	5.36617	0.000	.79369	1.77640

ANALYSIS OF VARIANCE

Tests of Signficance for PRONE POS (25 M) using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Error 1	13.05	27	0.48		
REGRESSION	0.55	1	0.55	1.13	0.297
SNOWSHOE	14.27	3	4.76	9.84	0.000

ANALYSIS OF VARIANCE

Regression Analysis for Error 1 error term
Dependent Variable.. PRONE POS (25 M)

COVARIATE	B	Beta	Std. Err.	t-Value	Sig t	Lower-95%	CL-Upper
MEASURE	-.03180	-.20065	.02988	-1.06426	0.297	-.09311	.02951

ANALYSIS OF VARIANCE

Tests of Signficance for PRONE POS (50 M) using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Error 1	10.32	27	0.38		
REGRESSION	0.11	1	0.11	0.30	0.589
SNOWSHOE	3.38	3	1.13	2.95	0.051

ANALYSIS OF VARIANCE

Regression Analysis for Error 1 error term
Dependent Variable.. PRONE POS (50 M)

COVARIATE	B	Beta	Std. Err.	t-Value	Sig t	Lower-95%	CL-Upper
MEASURE	-.01452	-.10462	.02657	-.54663	0.589	-.06905	.04000

APPENDIX H

ANOVA OF DONNING AND DOFFING TIMES

ANOVA OF DONNING AND DOFFING TIMES

ANALYSIS OF VARIANCE

Tests of Signficance for DONNING using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Error 1	8497.55	10	849.76		
HAND	24332.39	1	24332.39	28.63	0.000

ANALYSIS OF VARIANCE

Tests of Signficance for BAREHAND-DONNING using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Error 1	4646.81	28	165.96		
SNOWSHOE	2927.07	3	975.69	5.88	0.003

ANALYSIS OF VARIANCE

Tests of Signficance for GLOVED-DONNING using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Error 1	31350.93	28	1119.68		
SNOWSHOE	35453.28	3	11817.76	10.55	0.000

ANALYSIS OF VARIANCE

Tests of Signficance for DOFFING using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Error 1	265.87	10	26.59		
HAND	491.78	1	491.78	18.50	0.002

ANALYSIS OF VARIANCE

Tests of Signficance for BAREHAND-DOFFING using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Error 1	228.52	28	8.16		
SNOWSHOE	36.34	3	12.11	1.48	0.240

ANALYSIS OF VARIANCE

Tests of Signficance for GLOVED-DOFFING using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Error 1	1188.27	28	42.44		
SNOWSHOE	241.22	3	80.41	1.89	0.153

APPENDIX I

PAIRED COMPARISON ANALYSES

PCSTAT: STATISTICAL ANALYSIS OF PAIRED-COMPARISION DATA

C.P. WHALEY UNIVERSITY OF WATERLOO

TITLE: Mobility & Human Factors Evaluation for Assault Snowshoes

NO. OF OBJECTS: 4
NO. OF SUBJECTS: 10

INCIDENCE MATRIX...

0.00	3.00	1.00	1.00
7.00	0.00	3.00	0.00
9.00	7.00	0.00	4.00
9.00	10.00	6.00	0.00

TRANSFORMED (LOGISTIC) DATA ...

X	A	Z-MATRIX			
-4.454	-1.113	0.000	-0.762	-1.846	-1.846
-3.045	-0.761	0.762	0.000	-0.762	-3.045
2.240	0.560	1.846	0.762	0.000	-0.368
5.258	1.315	1.846	3.045	0.368	0.000

VARIANCE MATRIX...

0.000	0.412	0.660	0.660
0.412	0.000	0.412	1.200
0.660	0.412	0.000	0.377
0.660	1.200	0.377	0.000

CR-MATRIX...

0.000	-1.187	-2.272	-2.272
1.187	0.000	-1.187	-2.779
2.272	1.187	0.000	-0.599
2.272	2.779	0.599	0.000

ESTIMATED Z-MATRIX...

0.000	-0.352	-1.674	-2.428
0.352	0.000	-1.321	-2.076
1.674	1.321	0.000	-0.754
2.428	2.076	0.754	0.000

ADDITIVITY TEST...

CHISQ = 4.843, DF = 3, P = 0.1836

ANALYSIS OF VARIANCE...

SOURCE	DF	SS	MS	F	P
BETWEEN OBJECTS	3	15.443	5.148	7.971	0.061
RESIDUAL	3	1.937	0.646		
TOTAL	6	17.380			

FOR INDIVIDUAL COMPARISON OF A-VALUES...

LSD = 3.541, P = .05

LSD = 6.176, P = .01

SCALED OBJECT INDICES...

```
------------------------------------------------------------------------
1          2                                        3                  4
------------------------------------------------------------------------
```

APPENDIX J

HYBRID SNOWSHOE COMMENTS

SUBJECT COMMENTS - HYBRID DESIGN

SUBJECT #1

Use Redfeather frame, add 1/2" width on each side.
Add teeth to the sides of frame for traverse traction.
Use decking of Atlas and crampons from Atlas.
Use ankle binding from Tubbs and toe binding from Atlas, however, replace velcro strap with a different buckle.

SUBJECT #2

The Atlas toe strap combined with the rear strap of the Redfeather.

SUBJECT #3

A snowshoe the size and shape of Tubbs, change decking to something that is not as slick.
Change crampon material to plastic or other material so it doesn't collect snow (build-up).
Add crampons on side or back to keep the heel from washing out on a traverse.
Keep the binding design basically the same, but insure that a NATO toed ski boot (75mm) will work.
The frame should be of some sort of square stock as it will help on the traverses and stability on unlevel ground.
On the shape, make a little wider on the outside, so it doesn't interfere with walking.
I like the size of the Tubbs, maybe a little wider.

SUBJECT #4

Build a snowshoe the Redfeather size with a Tubbs binding with the strength of a Standard Magnesium.
Ensure that the Atlas crampons are used.

SUBJECT #5

The Tubbs are my favorite, good flotation.
Modify the toe section of the binding.
Add some small crampons near the rear of the tail with some small crampons on the side to help traversing a side slope.
Redesign the crampons so they don't collect snow & ice. (Like the Atlas crampons.)

SUBJECT #7

Atlas snowshoe with Tubbs bindings and Tubbs size with teeth on side for better stability for traverse.

SUBJECT #8

Atlas snowshoe with Redfeather tail length and design.

Long straps as well, except for non-adjustable lateral strap.

Binding would also be compatible with VB Boot and NATO Ski Boot (75mm toe).

SUBJECT #9

Ideal Snowshoe: Use Redfeather shoe with Tubbs bindings with Atlas crampons.

Size should be halfway between the Redfeather and Standard shoe.

Make Tubbs binding straps approximately two inches longer to accommodate the larger boots.

SUBJECT #10

Take a Tubbs shoe, add the crampons from the Atlas. Replace those laces with something more like the decking on the Atlas.

Lengthen the toe strap to make it easier to adjust.

SUBJECT #12

Need the frame of the Tubbs with the decking of the Standard, the teeth on the crampons of the Atlas, and the bindings of the Atlas with a consideration for boot sizes.

APPENDIX K

PHOTOGRAPHS OF DESIGN SHORTCOMINGS

PHOTOGRAPHS OF DESIGN SHORTCOMINGS

Figure K-1. The front toe strap is too short to grasp by users wearing vapor barrier boots.

Figure K-2. Ice and snow accumulation on hook and pile closure (see arrows).

Figure K-3. Subject slipping when traversing steep slope.

Figure K-4. Heel strap that loosened and slipped off when subject descended steep slope.

Figure K-5. Snowshoes kick up snow, creating billowy cloud around marine who is running an assault.

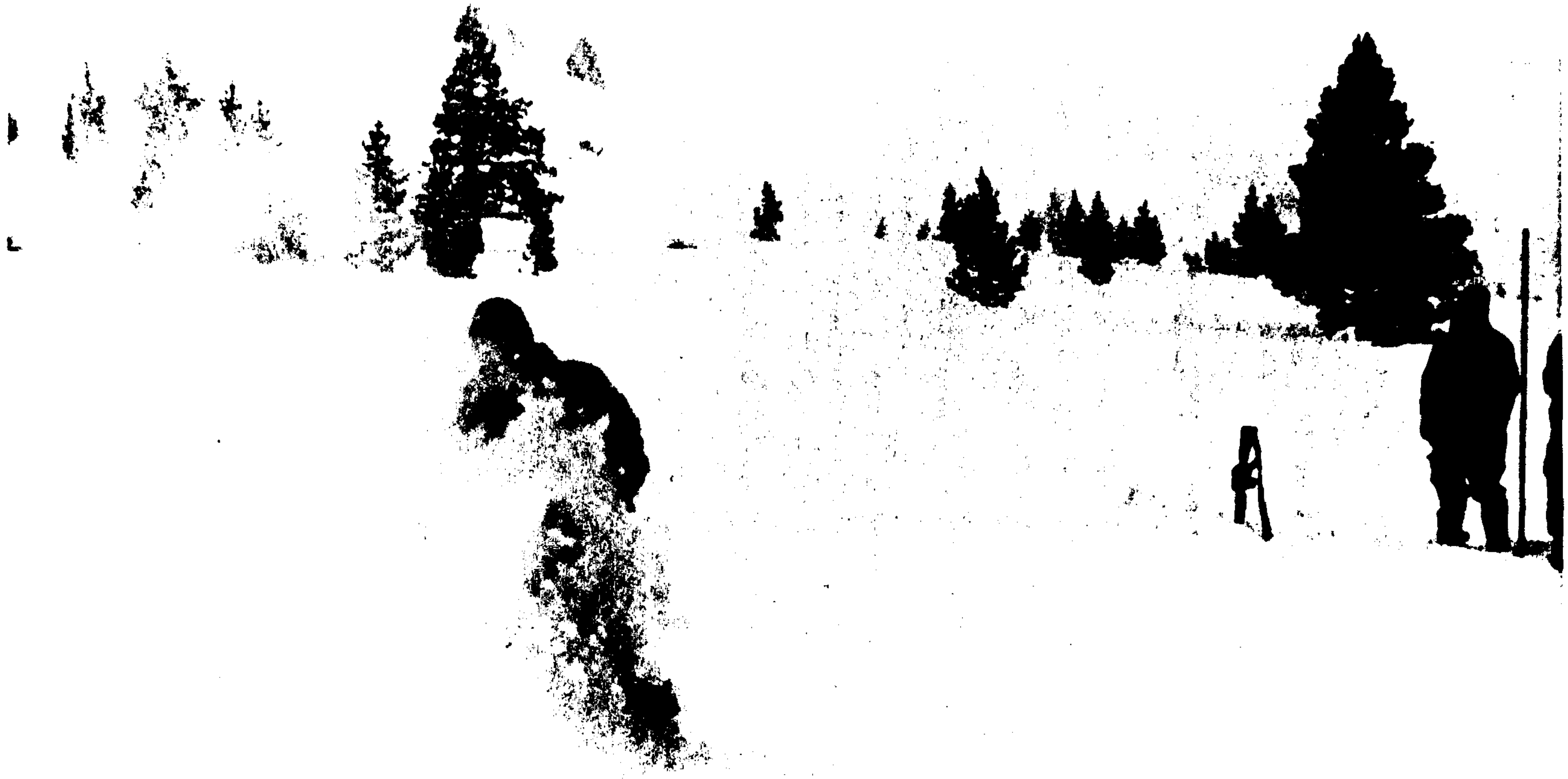

Figure K-6. Snowshoes kick up snow, creating billowy cloud around marine who is running an assault.

Figure K-7. Arrows denote foremost portion of binding. (Note the size and shape and how the boot toe fits into the opening in the binding.)

Figure K-8. The arrow points to snow accumulation on the crampon of Snowshoe C.

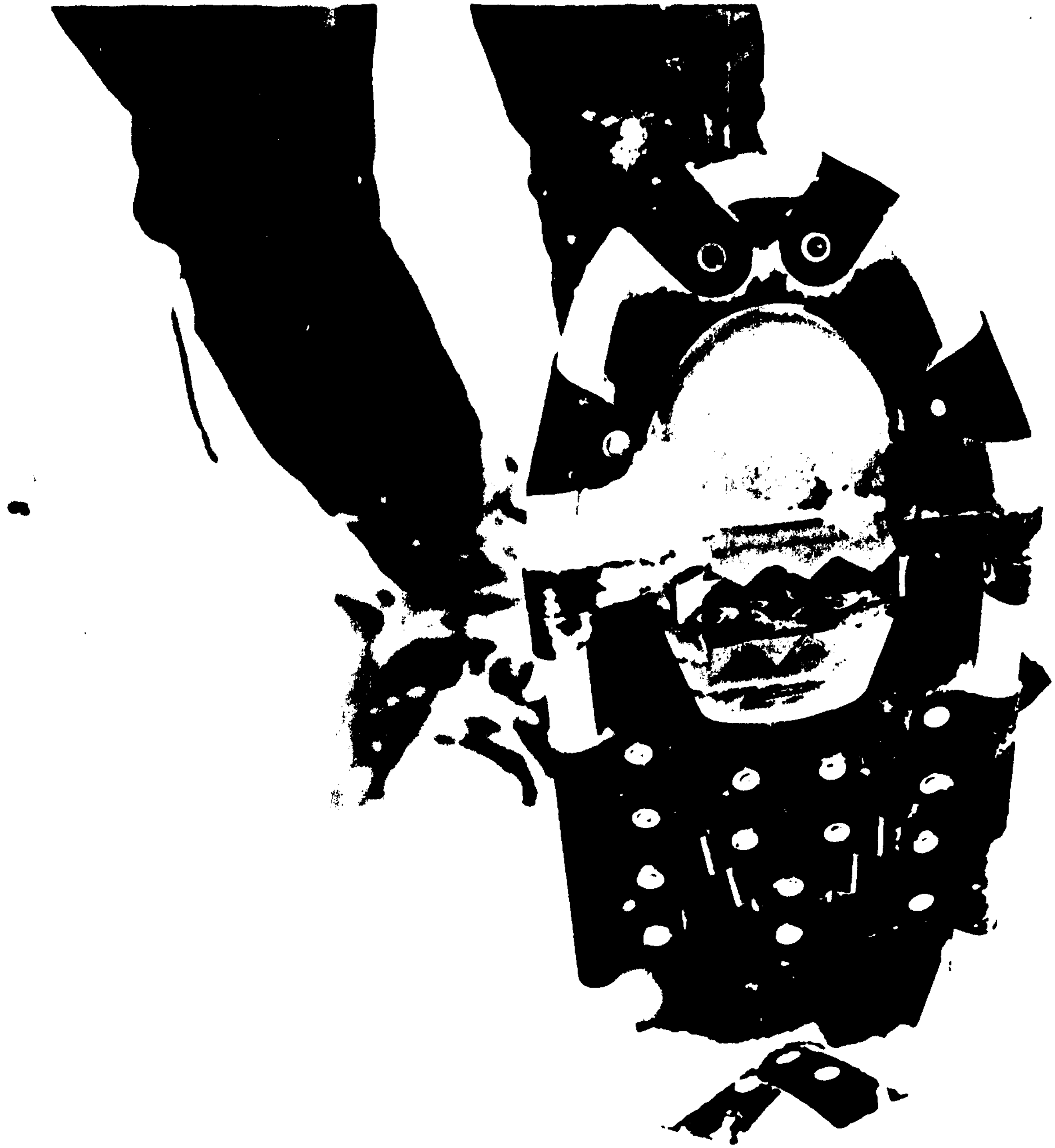

Figure K-9. Snowshoe A had little or no snow accumulation on its crampons.

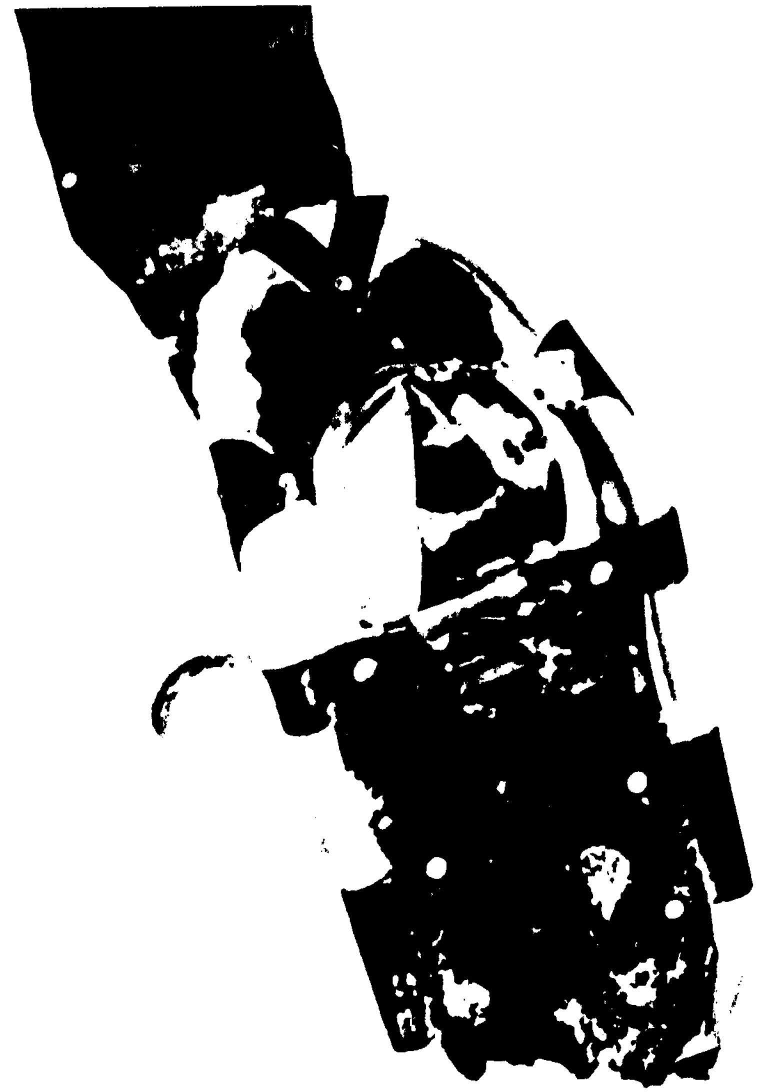

Figure K-10. Snowshoe B had little or no snow accumulation on its crampons.

Figure K-11. A subject is holding a snowshoe that fell off during an assault on the course.

Figure K-12. A snowshoe fell off when the subject assumed the prone firing position.